Closeout Report on the DOE/SC Review of the

Proton Improvement Plan (PIP-II)

Fermi National Accelerator Laboratory

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Committee Chair

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http://www.science.doe.gov/opa/

Review Committee Participants

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Review Committee

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Charge Questions

1. Is the proposed technical concept, including both new construction and modifications to existing infrastructure, likely to satisfy the P5 recommendation? Are there major alternative technical choices? How well understood are the international in-kind contributions?

2. Is the presented cost range based on sound reasoning, consistent with experience of similar projects? Is it likely to bound the actual cost when PIP-II is built?

3. Does the scheduling strategy fit with other major projects at Fermilab?

4. Is there significant R&D that still needs to be carried out in order to implement the proposed concept? Are all the significant technical and cost risks identified? Does the laboratory have a plan, and sufficient resources, to complete the R&D in a timely manner?

5. Does the management team possess the requisite expertise and experience? Is it appropriately organized and staffed to initiate PIP-II activities?

Charge Question 1

- Is the proposed technical concept, including both new construction and modifications to existing infrastructure, likely to satisfy the P5 recommendation?
  - Yes, but it will take a concerted effort to complete both the R&D phase and commissioning of the beam line chain (linac, booster, recycler and MI) on the time scale proposed.
  - The RDR is a great start on the CDR in addressing technical issues, but plans beyond installation are not well defined, in particular, the strategy for transitioning to the new proton source. Also, there is not a clear delineation of initial versus future capabilities.
- Are there major alternative technical choices?
  - Major alternatives were not addressed in this review
- How well understood are the international in-kind contributions?
  - The in-kind contribution plan is still evolving, but is a great win-win strategy for this program, with both development and acquisition risks being shared roughly equally with the Indian collaboration.

Charge Question 3

- Does the scheduling strategy fit with other major projects at Fermilab?
  - Without a resource loaded schedule, a facilities sharing plan and a fairly mature acquisition strategy, it is hard to answer this question at this time.
  - The facilities for PIP-II still need a lot development to allow both LCLS-II production and PIP-II R&D to proceed with minimal interference.
  - As noted above, a detailed plan for transitioning to the new source has not been developed. In particular, the experimental program schedule has not be integrated with PIP-II, including contingency plans.

Charge Question 4

- Is there significant R&D that still needs to be carried out in order to implement the proposed concept? Are all the significant technical and cost risks identified? Does the laboratory have a plan, and sufficient resources, to complete the R&D in a timely manner?
  - The R&D required is extensive but the plan is well developed and aimed appropriately at the major risks, which we categorize below.
  - Beam Transport – moderate – there are a number of challenges to increase the bunch charge and rep rate that are being addressed – individually, they are not insurmountable (the MAC review gives specific concerns), but collectively, they pose a risk to a smooth turn on.
  - SC Accelerator – low to moderate – the designs are fairly mature for the pre-CD0 phase and are not large extrapolations from existing ones. The gradient stabilization will be challenging, but likely achievable, especially if the cavity fill period is lengthened, which the large cryogenic overhead should allow.

Question 4 Continued

- Is there significant R&D that still needs to be carried out in order to implement the proposed concept? Are all the significant technical and cost risks identified? Does the laboratory have a plan, and sufficient resources, to complete the R&D in a timely manner?
  - Schedule – high – the engineering design and development for 5 types of cryomodules is daunting and has not been worked out in detail
  - Costs – low - the linac component costs do not seem out of line with other projects (SNS and LCLS-II). However EDIA type costs are not fully developed (i.e., only 10% on cavities and cryomodules, and none on some of the other major items)
  - R&D – moderate – The cavities will likely operate at the design gradients, but meeting all requirements (vacuum, cooling, conditioning, regulation) will likely take longer than planned.
    - Would be helpful to use as many common parts as possible.

Recommendations

- Priorities for going forward to CD1 once CD0 approved
  - Develop resource loaded R&D schedule and plan for developing the facilities for doing this work
  - Development (defining specs, vendor selection and qualification, reviews, etc.) costs and schedule need to be more realistically estimated.
  - The costs (and schedule risks) for providing CW capabilities need be estimated as well as any additional costs to eventually run the 800 MeV linac with 2 mA beams.
  - High priority should be given to beam physics verification, in particular, booster impedance studies and slip stacking.
  - A unifying plan to deal with the large number of SC components and vendors should be developed.

2. Is the presented cost range based on sound reasoning, consistent with experience of similar projects? Yes. Is it likely to bound the actual cost when PIP-II is built? Yes.

4. Is there significant R&D that still needs to be carried out in order to implement the proposed concept? Yes. Are all the significant technical and cost risks identified? Yes on technical. Somewhat on cost risks. Does the laboratory have a plan, and sufficient resources, to complete the R&D in a timely manner? Yes.

Findings

- **High end TPC is $695M. Point cost estimate is $382.3M. Delta is $312M.**
- **The planned CD-4 date is FY 2024**
- **Basis of estimates include vendor quotes, historical data, benchmarking with similar projects (SNS).**
- **Escalation is 2.4% which is applied from 2013 to FY2020**
- **Technical risks have been identified**
- **Activities with cost estimates developed at Level 2 and 3 WBS**
- **CD-4 completion includes international contributions**

Findings con't

- **The assumed funding profile for the mid-range estimate is shown below.**

	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	TOTAL
R&D	$16.0	$24.0	$30.2	$18.7	$0.0	$0.0	$0.0	$0.0	$0.0	$88.9
Civil	$1.0	$1.5	$11.0	$20.0	$36.0	$30.0	$14.0	$6.5	$0.0	$120.0
Management	$1.8	$5.0	$8.5	$9.2	$10.0	$10.3	$10.8	$10.8	$8.5	$74.9
Construction	$0.0	$0.0	$0.0	$33.0	$33.0	$40.0	$55.2	$55.8	$15.3	$232.3
Carryover	$0.7	$1.7	$12.0	$11.1	$12.1	$11.8	$11.8	$8.7	$0.0	
TOTAL (new BA)	$19.5	$31.5	$60.0	$80.0	$80.0	$80.0	$80.0	$70.0	$15.1	$516.1

Comments

- **Project is well beyond CD-0 stage**
- **PIP-II cost estimates are well within the SNS actual costs for similar scope**
- **Presented cost range appears sound and consistent with similar projects**
- **Resource conflicts with LCLS II can be managed by utilizing expertise from the Indian engineering staff**

Recommendations

1. **Prior to CD-0, escalate all labor costs from FY13 to FY24 to evaluate the cost differences from FY2013 to FY2020**
2. **Prior to CD-0, determine funding profile for the higher end TPC of $695M for the Mission Need Statement**

3. Does the scheduling strategy fit with other major projects at Fermilab? *Yes, however we have some concerns noted in comments.*

4. Is there significant R&D that still needs to be carried out in order to implement the proposed concept? *Yes, and it is underway.* Are all the significant technical and cost risks identified? *We believe so based on talks, but analysis should continue.* Does the laboratory have a plan, *Yes* and sufficient resources *Probably*, to complete the R&D in a timely manner?

5. Does the management team possess the requisite expertise and experience? *Yes* Is it appropriately organized and staffed to initiate PIP-II activities? *Yes, once noted hires are made*

Findings:

- The notional schedule for PIP-II is based on the premise that 1.2 MW beam will need to be delivered to LBNF on the order of 2024-25. Critical decisions are derived by working backwards from this date. This leads to a CD-3 in 2019, CD-2 in 2018, CD-1 in FY17, and a CD-0 near the end of FY2015.
- Much of the technical design, management structure, and international collaboration of PIP-II is based on years of activity related to Project-X.
- The international collaboration with India has been functioning since 2007 in support of R&D relevant to PIP-II.

Comments:

- The proposed schedule appears reasonable to meet the CD-4 beam delivery date by 2024-2025. In order to meet this, the funding profile needs to be sufficient, and CD-0 is needed in the next year.
- The committee is somewhat concerned that the notional schedule shows the Fermilab complex shutting down to install LBNF and PIP-II at the same time. This is an efficient use of downtime, but puts great pressure on PIP-II to perform quickly and deliver for an experiment that will expect high power. Fermilab needs to monitor this schedule strategy as the project progresses.
- Charge question 3 asks how the schedule fits with other Fermilab projects. It is difficult to answer this without a full description of other projects, and without a resource loaded scheduled for PIP-II. This will come and is the focus of a recommendation.
- Project scope appears to be well defined, including items that are not part of the Superconducting Linac. The project should be continue to ensure the scope is carefully defined, particularly that which is not related to the linac.

Comments: continued

- ES&H issues are well understood and planned
- NEPA issues are well understood and planned
- The experience with Indian labs and industry during the R&D phase has been positive and leads to optimism that this agreement will deliver during the construction phase.
- The execution of the R&D plan, both at Fermilab and in India should be carefully monitored over the next three years to ensure that the plan is executed as outlined. Formal documentation of reviews should be regularly captured by project management. These reviews should address resource allocation. (Recommendation follows)
- As this project is not yet to CD-0, a resource loaded schedule (RLS) has not been developed. However, the development of an RLS including the R&D activities, will answer many questions raised at this review, and should be a high priority once CD-0 is awarded. (Recommendation follows)

Comments: continued

- At CD-1, design alternatives should consider any impact of PIP-III requirements on PIP-II design.
- The management team is very experienced and has good track record. Succession planning for potential departures is in place, and we encourage continued planning.

Recommendations

1. Throughout the remaining R&D phase, perform regular reviews on the status of the execution of the R&D plan.
2. Once CD-0 is awarded place emphasis on the development of a RLS.